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Rainfall, Runoff, Soil and Nutrient Loss Relationships Under Cassava+Pineapple Strip Cropping in Humid Tropical Kerala, India

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Abstract

In many regions of the humid tropics of Kerala, nutrient losses due to soil erosion are extremely large because of the sloping terrain coupled with heavy rainfall. This is one of the main factors limiting soil fertility and crop yields. Hence the present study was taken up to assess the runoff, soil loss and subsequent nutrient losses in cassava and pineapple strip cropping in humid tropical Kerala. Treatments included cassava alone and cassava with pineapple strip cropping. The surface runoff of different rainfall events (classified as low, medium and high) was collected in the first tank, which overflowed into a second tank via a multi-slot (thirteen-slot) devisor that allowed the overflow into the other tank. Volume of flow collected in these tanks was considered as plot runoff. The total amount of eroded soil was estimated by filtration of a composite sample collected from both the tanks after thoroughly mixing the runoff and sediment collected in them. The dried samples were analyzed for C, N, K, Ca and Na by adopting standard methodologies. The results indicated that the soil loss of cassava alone plot was high (0.13-139.00 t ha^{-1}), whereas in the cassava and pineapple strip cropping it was 0.0-8.28 t ha^{-1} for different rainfall events of low to high. The nutrient content in the eroded soil was significantly greater than the initial soil nutrient content of these plots, indicating that the eroded particles were finer in composition. The quantity of nutrient loss was significantly greater under cassava alone plot due to greater quantity of runoff and eroded soil. The study indicated that cassava + pineapple strip cropping was an effective strategy for arresting the soil erosion from cassava fields under steep slopes.

Key words: Cassava + pineapple, strip cropping, soil erosion, nutrient loss, rainfall

Introduction

Soil is an important natural resource for all land use activities to meet the requirements of food, feed, fuel, fibre etc. of mankind. Managing this resource on sustained basis is one of the vital issues under the present scenario, when the pressure on soil is increasing day by day. It is estimated that out of 329 m ha of total geographical area in India, about 146.82 m ha suffers from soil erosion and land degradation (Sehgal and Abrol, 1994). In India, on an average, annual top soil removal due to soil erosion is to the tune of 53,500 m t. Kerala enjoys a typical humid tropical climate with high intensive rainfall and alternate wet and dry periods. Kerala is gifted with distinct altitudinal variations resulting from the rise of the land mass from 5 m below sea level to the soaring heights of 2695 m above mean sea level within the short span of 120 km. The topography of the land in Kerala plays a major role in erosion. The rainfall is of high intensity (60 mm h^{-1}) and the average annual rainfall ranges between 1500 and 3000 mm within a short span of 6 to 7 months. Heavy downpours occurs in short spell during the monsoons. Aerial distribution of slope classes indicates that 87 % of the land is characterized by slopes where unscientific and indiscriminate land use intensify the erosion. The major portion of the state is lateritic and as such these soils are porous in nature, coarse texture and medium to low in cohesiveness and more prone to soil erosion. On an average 15-18 t ha^{-1} of top fertile soil is eroded in Kerala, ultimately resulting in low fertility status besides having other implications like low crop productivity, ground water recharge etc. (State of Environment Report Kerala, 2007).

Cassava is a major staple food in the developing world, providing a basic diet for about 502 million people (FAO, 2009). The area under cassava in India during 2011 was 2,21,400 ha with a productivity of 36.47 t ha^{-1} and in Kerala the area was 72,284 ha with a productivity of 33.32 t ha^{-1}. The perception that cassava degrades soils may be correct if the crop extracts large amounts of nutrients and/or causes severe erosion if it has slow initial growth rate thus resulting in soil degradation as a result of heavy rains (Putthacharoen et al., 1998). Erosion on sloping land is regarded as the major type of environmental damage in South East Asia with adverse impacts on soil fertility and water availability. Quantitative measured data on the dimension and extent of soil erosion are, however, scarce and are still typically lacking in many regions of the world (Erenstein, 1999). Keeping all these points in view, a study was conducted to assess the runoff, soil loss and subsequent nutrient losses under cassava and pineapple strip cropping in humid tropical Kerala.

Materials and Methods

The experiment was conducted at Centre for Water Resources Development and Management (CWRDM), Kunnamangalam, Calicut, Kerala, located in the southern part of India. The initial soils of the experimental fields were analyzed for their physico-chemical properties. Cassava variety, Vellayani Hraswa obtained from the Agricultural Research Station, Anakayam, Kerala Agricultural University was used for the study. Cassava was planted on 23 June 2012 and pineapple was planted three seasons before the experiment. The cultural and management practices were followed as per the Package of Practices recommendations of Kerala Agricultural University.

The plot size was 27 x 6 m. The plots were bordered with G.I. sheets and placed vertically to avoid the runoff moving outward the plots and similarly to prevent the outside run off entering into the plots. Cassava alone and cassava with pineapple strip cropping were taken as the treatments with three replications. The surface runoff from the two plots (cassava alone and cassava with pineapple srip cropping) was collected separately for the classified low, medium and high rainfall events. The rainfall received was classified into low, medium and high rainfall events mainly to assess the runoff, soil loss and nutrient loss from the cassava plot. Less than 20 mm rainfall per day was considered as low rainfall event, 20 to 50 mm of rainfall per day was considered as medium rainfall event and more than 50 mm was considered as high rainfall event.

Water and the sediments were collected in a concrete tank of volume 325 l which also overflowed into a second tank of volume 300 l via a multi-slot (thirteen slot) divisor that allowed the overflow into the other tank. A view of the experimental plot is shown in Fig. 1. Volume of flow collected in these tanks was considered as plot runoff. The total amount of eroded soil was estimated by filtration of a composite sample collected from both the tanks after thoroughly mixing the runoff and sediment collected in them (Heron, 1990; Hudson, 1993). Water sample for nutrient and soil loss were collected daily and filtered. All the tanks were emptied and cleaned after samples were collected. The sediment retained after filtration was weighed and dried at room temperature (30-40^{o}C) for 78 h. The dried sediment samples were analyzed in the laboratory for the total nutrient losses for C, N, K, Ca, and Na by adopting standard methodologies. Students t-

Fig.1. A view of the experimental plot

test was carried out to test the significants difference between treatments with respect to nutrient loss.

Results and Discussion

The site characteristics and physico-chemical properties of the experimental field are given in Table 1. The climate of the experimental site is humid tropical with hot dry summers and cold winter season. The rainfall received during the experimental period was 2121 mm and nearly 80% of the rainfall was received during South-West monsoon season during May to September. The soil is lateritic and taxonomically belongs to Kunnamagalam series with USDA class of Mixed; Isohyperthermic, Typic Kanhaplustults. The soils are sandy loam with 62 % sand, 20 % silt and 18 % clay. Chemically, the soil was acidic and low in fertility (Table 1).

Quantity of runoff and soil loss from both the plots is presented in Table 2. The results revealed that the quantity of soil loss was high under high rainfall event and was low in the case of low rainfall events. It was also observed that the soil loss of cassava alone plot was high and it ranged between 0.13 and 139.00 t ha^{-1}, whereas under cassava with pineapple strip cropping it ranged between 0.0 and 8.28 t ha^{-1} for different rainfall events of low to high. However, previous studies conducted at Central Kerala to compare between bare soil and cassava in a sandy clay loam soil with 15% slope showed that soil and runoff losses were significantly higher in bare fallow than cassava (Viswambharan and Sasidhar, 1985). Similar studies in a cassava based multiple cropping system in South Kerala on a sandy clay loam soil with 8 to 9% slope, indicated that maximum soil loss again occurred under bare fallow. By planting cassava alone on staggered mounds the soil loss could be reduced by 45% compared with bare fallow. Intercropping cassava with perennial trees (banana and eucalyptus) reduced the soil loss to only 22% (Ghosh et al., 1987). In this study, the quantity of nutrient loss was significantly greater under cassava alone plot than with the cassava + pineapple strip cropping and this was because the total quantity of runoff and eroded soil in the plot was high. The earlier erosion studies conducted in both North and South Vietnam indicated that runoff and erosion losses can be markedly reduced in cassava by intercropping and planting in contour hedgerows (Putthacharoen et al., 1998). The system of intercropping cassava with maize and upland rice followed by soybean also produced much less erosion than growing cassava in monoculture (Wargiono et al., 1998).

Table 1. Characteristics of the experimental area

Site characteristics	
District	Kozhikode
Latitude/Longitude	11°17'07"E/75°52"15"N
Mean annual maximum temperature (°C)	34.6 (April)
Mean annual minimum temperature (°C)	18.9 (December)
Mean annual rainfall (mm)	3438
Soil type	Lateritic soil
Plot size	27 m x 6 m
Slope (%)	50
Soil characteristics	
Soil series	Kunnamangalam
Texture	Sandy loam
pH	4.76
EC (dS m^{-1})	0.01
Organic C (%)	0.86
Available N (kg ha^{-1})	218.8
Olsen-P (kg ha^{-1})	10.0
Exchangeable K (kg ha^{-1})	970.0
Exchangeable Ca (mg kg^{-1})	11.4
Exchangeable Na (mg kg^{-1})	4.4

Intercropping with peanut was generally more effective in reducing erosion than intercropping with other crops, due to the rapid canopy closure. In this study also strip cropping of pineapple across the slope acted as a barrier for the eroded soils. It has been observed that only under high rainfall events there was the possibility of runoff and soil loss even from cassava + pineapple strip cropping and there was no run off and soil loss under low rainfall events. This indicated that cassava + pineapple strip cropping was an effective strategy for arresting the soil erosion from cassava fields under steep slopes.

The nutrient content in the eroded soil was significantly greater than the initial nutrient status of these plots, indicating that the eroded particles were finer in composition with high fertility (Fig. 2). Organic residues are among the first constituents to be removed by erosion because they are concentrated on the surface soil and are less dense than the other soil constituents. Even with

Table 2. Quantity of soil loss from the run off plots

No. of events	Date of occurrence	Rainfall (mm day^{-1})	Soil loss (kg plot^{-1})		Soil loss (t ha^{-1})	
			Cassava alone	Cassava + pineapple strip cropping	Cassava alone	Cassava + pineapple strip cropping
High rainfall events						
1	8/17/2012	89.0	60.37	3.59	139.31	8.28
2	8/30/2012	60.2	47.70	0.08	110.07	0.18
3	7/2/2012	57.8	13.74	0.15	31.70	0.34
Medium rainfall events						
4	7/10/2012	23.6	0.76	_	1.75	Nil
5	8/29/2012	27.2	0.24	_	0.55	Nil
6	9/4/2012	29.0	0.55	0.26	1.26	0.60
Low rainfall events						
7	7/4/2012	14.4	1.10	_	2.53	Nil
8	9/15/2012	11.0	0.17	_	0.39	Nil
9	7/9/2012	5.6	0.06	_	0.13	Nil

similar density, fine soil fractions are known to erode more easily than coarse fractions (Kinnell, 2005), because fine fractions take longer to settle in runoff water than coarse fractions. Most soils tend to lose a greater percentage of organic matter and fine material when sediment concentration of runoff water is low than when it is high. This selective loss of soil components rich in nutrients is believed to arise from the type of erosion processes involved.

The nutrient loss from the cassava plot and cassava with pineapple strip cropping revealed a significant difference between these plots with respect to N, K, Ca and Na. The values were statistically significant at 95% confidence level when compared with the control treatment with student-t test. Similarly the nutrient loss in runoff water obtained from these plots also showed a similar trend, except for Ca (Table 3). This is contrary to the earlier reports of Zobisch et al. (1995), where they concluded that the nutrient loss was not significant between the erosion plots of bare field and that with maize and beans. This significant difference between cassava alone and cassava with pineapple strip cropping may be due to the fact that the pineapple strip cropping might have acted as a barrier row for the movement of fine soil particles and hence the eroded soil from pineapple may be of coarser fraction, which may be low in fertility (Kinnell, 2005).

Conclusion

The present study indicated that the soil loss under cassava and pineapple strip cropping was low when compared to cassava alone plot for different rainfall

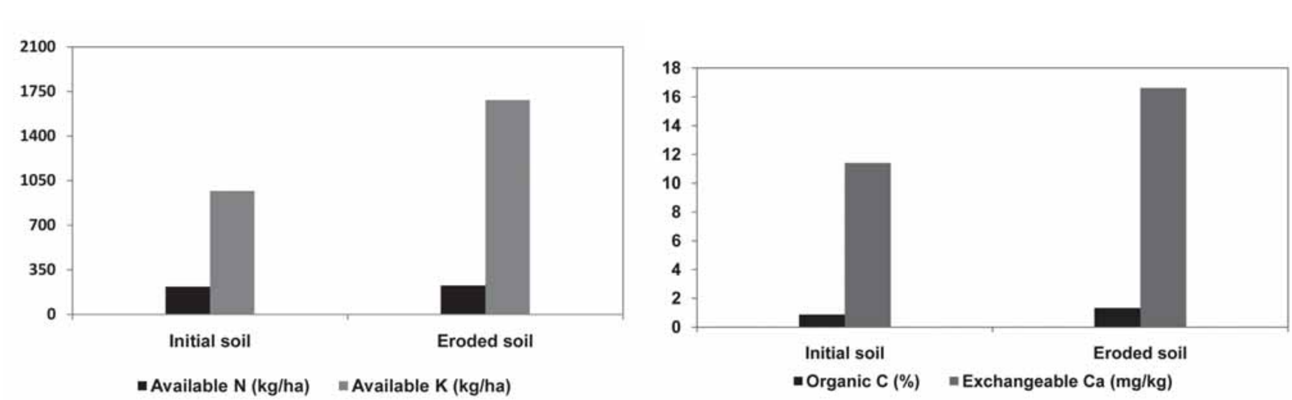

Fig. 2. Soil nutrient content of the initial soil and eroded soil

Table 3. Quantity of nutrient loss from the runoff water and soil

Treatments	Runoff water				Soil			
	N	K	Ca	Na	N	K	Ca	Na
	(mg kg^{-1})				(kg ha^{-1})		(mg kg^{-1})	
Cassava alone	1.5	1.1	4.7	1.1	243.6	2000.8	18.8	1.9
Cassava with pineapple strip cropping	0.9	0.8	4.2	0.3	210.0	1684.2	14.4	1.1
t stat*	5.16	3.82	NS	6.63	4.23	4.17	5.6	5.79

*Significant at $p < 0.05$

events of low to high. The nutrient content in the eroded soil was significantly greater than the initial soil nutrient content of these plots, indicating that the eroded particles were finer in composition. The quantity of nutrient loss was also significant between both the treatments and it was greater under cassava alone plot. It is recommended that strip cropping of cassava with pineapple across the slope can be adopted in Kerala.

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